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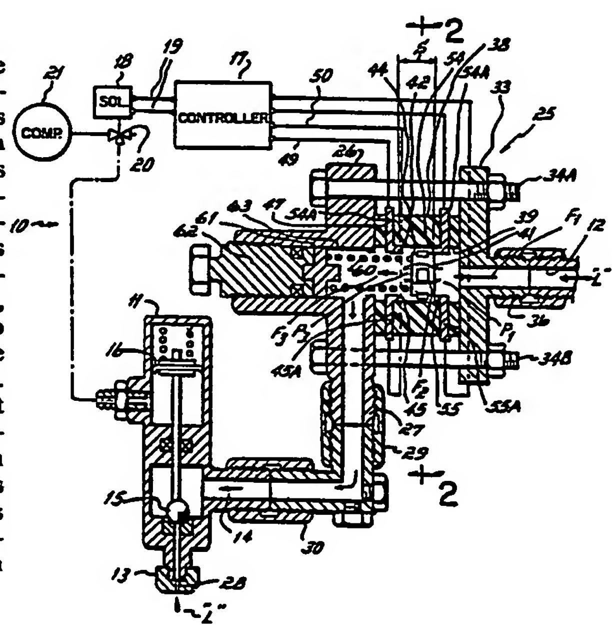
(54) Title: APPARATUS AND METHOD FOR DETECTING CLOGGING IN A FLUID DISPENSING SYSTEM

(57) Abstract

A method and apparatus for detecting clogging of the fluid flow path (12) of either continuous or intermittent dispensing systems wherein a movable, flow-restricting element (41) is located in the fluid flow path (12) for movement between a downstream position at which, the position of element (41) is sensed by a first pair of contacts (44, 45) and an upstream position at which, the position of the element (41) is sensed by a second pair of contacts (54, 55). Element (41) is biased toward its upstream position by a spring (60) which exerts a force on element (41) that is small enough to be overcome under normal, unclogged operating conditions by an opposing force tending to move element (41) downstream as the result of the pressure drop across element (41) when flow is not impeded by clogging. In intermittent operation, the time required to displace element (41) between its upstream and downstream positions is compared with time limits representing unclogged operation and an alarm is generated if an abnormal change occurs. In continuous operation, an alarm is generated if element (41) either moves away from contacts (44, 45) at its downstream position or engages contacts (54, 55) at its upstream position at a time when dispensing is being demanded.



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APPARATUS AND METHOD FOR DETECTING CLOGGING IN A FLUID DISPENSING SYSTEM

Field of the Invention

The invention relates to detecting clogging in a fluid dispensing system. More particularly, the present invention relates to an apparatus and method for detecting clogging of intermittent and continuous fluid dispensing systems in accordance with the displacement of a movable flow-restricting element disposed in the flow path of the fluid.

Background of the Disclosure

Various systems for detecting clogging of fluid dispensing devices are known in the prior art. One such apparatus and method is illustrated in commonly assigned U.S. Patent 4,430,886 to ROOD. According to the ROOD patent, a fluid dispenser includes a valve located adjacent a fluid outlet nozzle as well as a restrictor located in the flow path upstream of the valve. A pressure transducer is located between the restrictor and the valve for measuring pressure drop when the dispenser valve is opened. A pressure drop of less than a predetermined amount is used to indicate a clogged nozzle. Another prior art technique involves detecting changes in the size of beads of fluid material dispensed onto a substrate as an indication of clogging. Such changes can be detected by sensing the amount of heat given off by the beads using infrared radiation sensing.

Summary of the Invention

It is an objective of the present invention to provide an apparatus and method for detecting clogging which can be adapted for use with both continuous and intermittent fluid dispensing systems, which is reliable and which can be implemented at a lower cost than prior art systems offering comparable performance.

It is a further objective of the present invention to provide an apparatus and method for detecting clogging in a fluid dispensing system based on the displacement of a movable, flow-restricting element located in the flow path between an upstream position and a downstream position.

It is yet a further objective of the invention to provide an apparatus and method of the above type which is capable of detecting either fully clogged or partially clogged conditions.

It is still a further objective of the present invention to provide an apparatus and method of the above type wherein a fully or partially clogged condition is determined based on the position of the movable element at a given time relative the occurrence of a dispenser valve control signal such as a signal to open or close the valve.

It is yet a further objective of the present invention to provide an apparatus and method

of the above type which can be readily adjusted to accommodate changes in system operating parameters such as changes in the makeup of the fluid being dispensed.

It is yet a further objective of the present invention to provide an apparatus and method of the above type wherein the position of the movable element is sensed electrically; for example, by means of at least one pair of contacts actuatable in response to the location of said movable element at either or both said upstream and downstream positions.

In furtherance of the above objectives, the present invention provides an apparatus and method for detecting full or partial clogging of the fluid flow path of a fluid dispensing system and includes a flow-restricting element located in the flow path and mounted for movement between an upstream position and a downstream position. In one preferred embodiment, the movable element is forcibly biased toward the upstream position with a force small enough to be overcome by an opposing force acting on the element due to the pressure drop across the element as the result of fluid flowing past the element when the flow path is not clogged. When the dispenser is open and in the absence of clogging, the opposing force acting on the movable element displaces the element

to the downstream position where its downstream travel is limited by a first pair of contacts which also serve to sense the presence of the element at the downstream location. In the event substantially full clogging occurs, the opposing force due to flow when the dispenser is open is insufficient to overcome the bias force. This causes the element to move to the upstream position at which second pair of contacts operate to sense that position of the element as well as to conveniently limit travel of the element in the upstream position. In a continuous dispensing system, a substantially fully clogged condition is indicated by the presence of the movable element at the upstream location when the dispenser should be open while a partially clogged condition is indicated by the presence of the movable element at a location intermediate the upstream and downstream positions at such a time.

In an intermittent dispensing system, a dispenser opens and closes intermittently in response to respective open and close signals. A further aspect of the present invention contemplates detecting clogging in such a system based on the time difference between the commencement of the "open" and/or "close" control signals and the time the movable element appears at the downstream and/or upstream positions, respectively. Still further

according to the invention, partial clogging can be distinguished from substantially full clogging of an intermittent system by comparing the actual time required to effect displacement of the movable element with predetermined time limits. If an "open" signal is applied to the dispenser and the movable element is not displaced downstream at least some distance away from the upstream position within a first time limit, a fully clogged condition is indicated. On the other hand, a partially clogged indication can be provided if the movable element is located intermediate the upstream and downstream positions after either or both of a second time limit following commencement of an open signal and a third time limit following commencement of a close signal.

These and other objects and advantages of the present invention will become even more clear upon review of the following detailed description of the preferred embodiment together with the accompanying drawings.

Brief Description of the Drawings

Fig. 1 is a partially cross-sectional schematic illustration of a fluid dispensing system embodying the present invention.

Fig. 2 is a sectional view taken along line 2-2 of Fig. 1.

Fig. 3A shows a front view of an alternate construction for the movable element shown in Fig. 2.

Fig. 3B is a side sectional view of the movable element of Fig. 3A together with the contacts of Fig. 1 shown in phantom lines.

Fig. 4 is a timing chart illustrating the operation of the embodiment of Fig. 1 wherein:

A illustrates the application of "open" and "close" control signals to the solenoid of Fig. 1.

B illustrates the response of the movable element of Fig. 1 under normal operating conditions, and

C illustrates the response of the movable element of Fig. 1 under partially clogged conditions, and

D illustrates the response of the movable element of Fig. 1 under substantially fully clogged conditions.

Detailed Description of the Preferred Embodiment

Referring now to Fig. 1, there is shown a fluid dispensing system 10 which includes a dispensing gun 11 connected to a fluid flow path 12 for continuously or intermittently dispensing fluid material such as liquid "L" from a nozzle 13. Gun 11 is connected to a pressurized supply (not shown) of liquid "L" by way of an inlet 14 which is separated

from nozzle 13 by way of a valve 15 that is selectively movable between an open position permitting flow of liquid "L" from nozzle 13 and a closed position (as illustrated in Fig. 1) effective to cut off the flow of liquid "L" from nozzle 13. Valve 15 is operated by a spring-loaded piston 16 under the direction of a controller 17. Controller 17 applies respective "open" and "close" control signals to a solenoid 18 which operates an air valve 20 connected to a source 21 of compressed air and to gun 11. In response to an "open" signal from controller 17, solenoid 18 operates valve 20 to connect gun 11 to compressed air source 21 thereby raising piston 16 against its spring load to open valve 15. When, controller 17 generates a "close" signal, solenoid 18 closes valve 20 in order to allow spring loaded piston 16 to close valve 15 to stop the flow of liquid "L" from nozzle 13.

According to the invention, a differential liquid pressure detector 25 is located in the fluid flow path 12 of system 10 between gun 10 and the pressurized supply of liquid "L" to which gun 10 is connected. Detector 25 includes a first fastening plate 26 having a central fluid outlet 27 which communicates with the inlet 14 of gun 11 by way of a suitable conduit 28 which may be secured by means such as removable couplings 29 and 30. Detector 25

further includes a second fastening plate 33 which is secured to plate 26 by a plurality of fasteners such as bolts 34A, 34B. Plate 33 includes a central fluid inlet section 36 which can be connected to a liquid feed device (not shown) either directly or by way of a flexible hose, a rigid pipe or a manifold (also not shown).

Clamped between plates 33 and 36, detector 25 further includes a thick-walled, cylindrical pipe 38 made of heat resistant, electrically insulating material. Pipe 25 defines a central bore 39 which communicates with inlet section 36 as well as outlet 27 to form part of the fluid flow path 12 which extends between the fluid source connected to inlet 36 and nozzle 13. A movable, flow-restricting element 41 in the form of an electrically conductive disk-shaped shift plate is slidably mounted within bore 39 for travel between a predetermined downstream position and a predetermined upstream position separated by a distance "S".

As can be seen with additional reference now to Fig. 2, element 41 may be formed with a series of spaced outwardly projecting tabs to provide a peripheral, flow-restricting gap 42 between pipe 38 and element 41 through which fluid material may flow in order to traverse element 41. Alternatively, element 41 can be formed to include one or more

flow-restricting orifices 43 as illustrated in Figs. 3A and 3B. The total cross-sectional flow area through gap 42 or orifice 43 is selected to be large enough to allow full normal flow but smaller than the cross sectional area of the flow path immediately upstream and downstream of element 41 in order to create a local flow restriction.

Travel of element 41 in the downstream direction is limited by a first pair of electrical contacts 44, 45 which project partially interiorly of bore 39 from holes 47 provided on opposing sides of pipe 38. Holes 47 receive metal fittings 44A, 45A which support contacts 44 and 45, respectively and which are electrically connected to controller 17 by way of respective wires 49 and 50 so that when element 41 is located at its downstream position, element 41 bridges contacts 44 and 45 to provide an identifiable electrical signal to controller 17. Travel of element 41 in the upstream direction is limited by a second pair of electrical contacts 54, 55 which face toward contacts 44 and 45 and are similarly mounted to pipe 18 by way of metal fittings 54A and 55A which are connected to controller 17 by way of wires 57 and 58, respectively. Thus, when element 41 is located at its upstream position, a second identifiable electrical signal is provided to controller 17.

Movable element 41 is forcibly biased toward its upstream position by a compression spring 60 captured between element 41 and a plug 61 mounted on the front end of an adjusting screw 62. Adjusting screw 62 is threadably mounted within a socket 63 formed in plate 26. The repulsive force, P_s, of spring 60 can be increased or decreased by turning adjusting screw 62 to accommodate changes in system operating parameters such as a changeover from dispensing one fluid material to dispensing another.

With additional reference now to Fig. 4, the method and operation of the apparatus of the invention as applied to an intermittent fluid dispensing system will now be explained. Controller 17 applies a series of intermittent "open" command signals of desired duration "T" to solenoid 18 to demand dispensing of liquid "L" from the nozzle 13 of gun 11. In intermittent operation, each "open" signal is preceded and followed by a "close" signal defining an interval during which flow from gun 11 is to be cut off by closure of valve 15. When valve 15 is closed and the liquid flowing through the flow path of system 10 remains stationary, the difference between the liquid pressure P1, upstream of element 41 and the liquid pressure P3, downstream of element becomes small. Hence, movable element 41 is pushed upstream by spring 60 until it is stopped at its

upstream position by contacts 54 and 55, its position there being sensed by controller 17 via wires 57 and 58.

When valve 15 opens in response to an "open" signal from controller 17 a liquid flow F1 upstream of element 41 begins. As a result, a flow F2 of liquid traverses gap 42 (or orifice 43 depending on the construction of element 41 which is used). Because the liquid encounters resistance to flow through gap 42 due to the restriction in cross sectional flow area imposed by gap 42, a pressure drop takes place across element 41. Accordingly, the pressure P3, downstream of element 41 becomes lower than the upstream pressure, P1. The repulsive force, P_s, acting on element 41 in the upstream direction is designed to be smaller in magnitude under normal, unclogged flow conditions than the opposing force acting on element 41 in the downstream direction due to the difference between pressures P1 and P3. As a result, under normal unclogged flow conditions when valve 15 opens element 41 is shifted to its downstream position where it is stopped by engagement with contacts 44 and 45, its position there thus being sensed by controller 17.

When valve 25 closes again in response to the next "close" signal generated by controller 17, the liquid pressure in the region of the flow path 12

between element 41 and valve 15 rises until it approaches the pressure P1 on the upstream side of element 41. When this occurs, spring 60 pushes element 41 back to its upstream position where element 41 is stopped due to engagement with contacts 54 and 55. Thus, element 41 shifts back and forth between its opposed upstream and downstream positions alternately opening and closing opposed pairs of electrical contacts 54, 55 and 44, 45, respectively.

Timing of the above-described operations under normal unclogged conditions can be more fully understood with reference to lines A and B of Fig. 4. Line A shows the application of alternating "open" and "close" electrical control signals to solenoid 18 over wires 19. Each "open" signal is represented as a positive-going pulse separated from preceding and succeeding "open" signals. Line B of Fig. 4 illustrates the shifting of element 41 between its downstream and upstream positions in response to the openings and closings of valve 15 initiated by the respective "open" and "close" signals of line A.

In normal intermittent operation in the absence of clogging, element 41 does not shift position instantaneously as "open" and "close" control signals are applied to solenoid 18. Rather, due to factors such as the time required for piston 16 to respond to a change in the electrical input to

solenoid 18 as well as the time delays required to transmit changes in liquid pressure to the vicinity of element and to move element 41 in response to those pressure changes, the actual movement of element 41 is delayed in phase by an amount, $\alpha 1$, following commencement of an "open" signal and by an amount, $\alpha 2$, following the commencement of a "close" signal as shown in line B of Fig. 4. Time limits based on these phase delays are stored in memory within controller 17. Provided significant clogging of the fluid flow path does not occur, controller 17 senses that element 41 is displaced to its downstream position, as sensed by closure of contacts 44, 45 within the predetermined time limit defined by delay $\alpha 1$ following commencement of an "open" signal. Likewise, controller 17 senses that element 41 is displaced to its upstream position, as sensed by closure of contacts 44 and 45, within the time limit defined by delay $\alpha 2$ following commencement of a "close" signal. Accordingly, no abnormal indication is provided by controller 17.

When clogging of the fluid flow path occurs, the pressure difference across element 41 when the valve 15 of gun 11 is open decreases. Where the clogging is only partial, as illustrated in line C of Fig. 4, element 41 can continue to shift between its full upstream and downstream positions but will

tend to move more slowly. As a result, element 41 will exceed the time limit defined by normal operating delay $\alpha 1$ by some additional amount of time, $\beta 1$, following the commencement of an "open" signal whereupon controller 17 generates an alarm or other appropriate signal indicative of a clogged condition. Controller 17 responds in the same fashion in the event the time limit defined by normal operating delay $\alpha 2$ is exceeded by some amount of time $\alpha 2$, following commencement of a "close" signal. When substantially complete clogging occurs, as illustrated in line D of Fig. 4, element 41 will remain at its upstream position in engagement with contacts 54 and 55 irrespective of the application of "open" signals to solenoid 18. In that event, an appropriate alarm or indication is provided by controller 17.

As will now be described, the invention can also be applied to continuous dispensing applications. Due to the flow restriction imposed by the presence of reduced area gap 42 or orifice 43, the liquid pressure P1 upstream of element 41 is always greater than the downstream pressure P3 as long as there is flow F2. As flow F2 increases, the pressure difference P1-P3 increases approximately in proportion to the square of the flow rate. However, when clogging of nozzle 13 occurs, the liquid pressure difference P1-P3 decreases approximately in inverse

proportion to the square of the flow rate. The repulsive force P_s exerted on spring 60 is precisely adjusted, using adjustment screw 62, to be just overcome by the opposing force generated by the pressure difference P1-P3 under normal, unclogged flow conditions so that under normal conditions element 41 will remain at its downstream position in engagement with contacts 44 and 45. In the event valve 15 or nozzle 13 becomes clogged, the liquid pressure difference P1-P3 normally present during continuous dispensing operation will decrease thereby decreasing the force opposing spring 60. As a consequence, element 41 will move upstream away from contacts 44, 45 whereupon an alarm or other appropriate signal indicative of a clogged condition will be generated by controller 17. In the event the clog is substantially complete, element will move to its upstream position engaging contacts 54 and 55 whereas if the clogging is only partial, element 41 will be positioned between its upstream and downstream positions intermediate contacts 44, 45 and 54, 55. Controller 17 can differentiate between these two conditions and provide signals indicating either a fully clogged or partially clogged condition as appropriate. Where, on the other hand, liquid continues to flow at a rate sufficient to maintain

element 41 in engagement with contacts 44 and 45 no abnormal indication is provided.

What is claimed is:

1. A method for detecting clogging in the fluid flow path of a fluid dispensing system, said method comprising the steps of:

(a) locating a flow-restricting element in the flow path, said element being movable between an upstream position and a downstream position;

(b) applying a bias force to said element in a direction tending to move said element toward said upstream position, said bias force having a magnitude small enough to be overcome by an opposing force generated by the pressure drop across said element due to the flow of the fluid traversing said element when the flow path is not clogged, and

(c) generating a signal indicative of a clogged condition in response to displacement of said element away from said downstream position toward said upstream position.

2. The method of claim 1 wherein said generating step comprises generating at least one of:

(i) a fully clogged signal in the event said element is displaced to said upstream position, and

(ii) a partially clogged signal in the event said element is displaced to a position intermediate said upstream position and said downstream position.

3. The method of claim 1 further comprising the step of adjusting said bias force to accommodate a change in at least one system operating parameter.

4. The method of claim 3 wherein said change in said system operating parameter comprises a change in the fluid material being dispensed.

5. The method of claim 1 wherein said generating step includes the step of monitoring displacement of said element using electrical means responsive to the presence of said element at said downstream position.

6. The method of claim 1 wherein said generating step includes the step of monitoring displacement of said element using electrical means responsive to the presence of said element at said upstream position.

7. The method of claim 1 wherein said generating step includes the step of monitoring displacement of aid element using electrical means responsive to the presence of said element at either said upstream position or said downstream position.

8. The method of claim 5 wherein said monitoring step includes the step of locating a first pair of contacts to be actuated in response to the presence of said element at said downstream position.

9. A method of detecting clogging in the fluid flow path of a fluid dispensing system of the type having a fluid dispenser which opens and closes intermittently in response to respective open and close signals, said method comprising the steps of:

(a) locating a flow-restricting element in the flow path, said element being movable in said flow path between an upstream position and a downstream position;

(b) applying a bias force to said element in a direction tending to move said element toward said upstream position, said bias force having a magnitude small enough to be overcome by an opposing force generated by the pressure drop across said element due to the flow of fluid traversing said element upon opening the dispenser when the flow path is not clogged to move said element toward said downstream position;

(c) monitoring the time difference between at least one of:

(i) the occurrence of the open signal and the displacement of said element to said downstream position, and

(ii) the occurrence of the close signal and the displacement of said element to said upstream position, and

(d) generating a signal indicative of a clogged condition in the event at least one of said time differences exceeds a predetermined limit.

10. The method of claim 9 wherein said generating step comprises generating at least one of:

(i) a fully clogged signal in the event said element is located at said upstream position, and

(ii) a partially clogged signal in the event said element is located at a position intermediate said upstream position and said downstream position.

11. The method of claim 9 wherein said partially clogged signal is generated in the event said element is located at said intermediate position after a time limit following at least one of:

(a) commencement of said open signal, and

(b) commencement of said close signal.

12. The method of claim 9 further comprising the step of adjusting said bias force to accommodate a change in at least one system operating parameter.

13. The method of claim 9 wherein said generating step includes the step of monitoring displacement of aid element using electrical means responsive to the presence of said element at said upstream position and said downstream position.

14. The method of claim 13 wherein said monitoring step includes the step of locating a first pair of contacts to be actuated in response to the presence of said element at said downstream position and locating a second pair of contacts to be actuated in response to the presence of said element at said upstream position.

15. The method of claim 9 wherein said monitoring step comprises monitoring the respective time differences between both:

(i) the occurrence of the open signal and the displacement of said element to said downstream position, and

(ii) the occurrence of the closed signal and the displacement of said element to said upstream position, and wherein said signal indicative of a clogged condition is generated in the event at least one of said time differences exceeds a predetermined limit.

16. An apparatus for detecting clogging in the fluid flow path of a fluid dispensing system, said apparatus comprising:

(a) a flow-restricting element in the flow path, said element being movable between an upstream position and a downstream position;

(b) force applying means for applying a bias force to said element in a direction tending to move said element toward said upstream position, said bias force having a magnitude small enough to be overcome by an opposing force generated by the pressure drop across said element due to the flow of the fluid traversing said element when the flow path is not clogged, and

(c) signal generating means for generating a signal indicative of a clogged condition in response to displacement of said element away from said downstream position toward said upstream position.

17. The apparatus of claim 16 wherein said signal generating means comprises means for generating at least one of:

(i) a fully clogged signal in the event said element is displaced to said upstream position, and

(ii) a partially clogged signal in the event said element is displaced to a position intermediate said upstream position and said downstream position.

18. The apparatus of claim 16 further comprising adjusting means for adjusting said bias force to accommodate a change in at least one system operating parameter.

19. The apparatus of claim 16 wherein said signal generating means includes electrical means responsive to the presence of said element at said downstream position for monitoring displacement of said element.

20. The apparatus of claim 16 wherein said signal generating means includes electrical means responsive to the presence of said element at said upstream position for monitoring displacement of said element.

21. The apparatus of claim 16 wherein said signal generating means includes electrical means responsive to the presence of said element at either said upstream position or said downstream position for monitoring displacement of said element.

22. The apparatus of claim 19 wherein said electrical means includes a first pair of contacts actuatable in response to the presence of said element at said downstream position.

23. An apparatus for detecting clogging in the fluid flow path of a fluid dispensing system of the type having a fluid dispenser which opens and closes intermittently in response to respective open and close signals, said apparatus comprising:

(a) a flow-restricting element in the flow path, said element being movable between an upstream position and a downstream position;

(b) force applying means for applying a bias force to said element in a direction tending to move said element toward said upstream position, said bias force having a magnitude small enough to be overcome by an opposing force generated by the pressure drop across said element due to the flow of fluid traversing said element upon opening the dispenser when the flow path is not clogged to move said element toward said downstream position;

(c) monitoring means for monitoring the time difference between at least one of:

(i) the occurrence of the open signal and the displacement of said element to said downstream position, and

(ii) the occurrence of the close signal and the displacement of said element to said upstream position, and

(d) signal generating means for generating a signal indicative of a clogged condition in the

event at least one of said time differences exceeds a predetermined limit.

24. The apparatus of claim 23 wherein said signal generating means comprises means for generating at least one of:

(i) a fully clogged signal in the event said element is located at said upstream position, and

(ii) a partially clogged signal in the event said element is located at a position intermediate said upstream position and said downstream position.

25. The apparatus of claim 23 further comprising adjusting means for adjusting said bias force to accommodate a change in at least one system operating parameter.

26. The apparatus of claim 23 wherein said signal generating means includes electrical means responsive to the presence of said element at either said upstream position or said downstream position for monitoring displacement of said element.

27. The apparatus of claim 26 wherein said electrical means comprises a first pair of contacts actuatable in response to the presence of said element at said downstream position and a second pair of contacts actuatable in response to the presence of said element at said upstream position.

28. The apparatus of claim 23 wherein said monitoring means comprises means for monitoring the respective time differences between both:

(i) the occurrence of the open signal and the displacement of said element to said downstream position, and

(ii) the occurrence of the closed signal and the displacement of said element to said upstream position, and wherein said signal indicative of a clogged condition is generated in the event at least one of said time differences exceeds a predetermined limit.

29. An apparatus for detecting clogging in the fluid flow path of a fluid dispensing system, said apparatus comprising:

(a) a flow-restricting element in the flow path, said element being movable between an upstream position and a downstream position;

(b) a spring acting on said element for biasing said element toward said upstream position with a force small enough to be overcome by an opposing force generated by the pressure drop across said element due to the flow of fluid traversing said element when the flow path is not clogged;

(c) sensing means for sensing the position of said element relative at least one of, said upstream position and said downstream position, and

(d) signal generating means connected to said sensing means for generating a signal indicative of a clogged condition when said element assumes a predetermined position at a time when dispensing of the fluid is demanded.

30. The apparatus of claim 29 wherein said sensing means comprises a first pair of contacts actuatable in response to the presence of said element at said downstream position.

31. The apparatus of claim 29 wherein said sensing means comprises a second pair of contacts actuatable in response to the presence of said element at said upstream position.

32. The apparatus of claim 29 wherein said sensing means comprises both a first pair of contacts actuatable in response to the presence of said element at said downstream position and a second pair of contacts actuatable in response to the presence of said element at said upstream position.

33. The apparatus of claim 30 wherein said first pair of contacts is at least partially disposed within the flow path and said element includes an electrically conductive region for electrically connecting said first pair of contacts through said region when said element is at said downstream position.

34. The apparatus of claim 31 wherein said second pair of contacts is at least partially disposed within the flow path and said element includes an electrically conductive region for electrically connecting said second pair of contacts through said region when said element is at said upstream position.

35. The apparatus of claim 33 wherein both said first and second pairs of contacts are at least partially disposed within the flow path and said element includes at least one electrically conductive region for electrically connecting, said first pair of contacts when said element is at said downstream position, and said second pair of contacts when said element is at said upstream position.

36. The apparatus of claim 30 wherein said first pair of contacts is engageable with said element to limit travel of said element in the downstream direction.

37. The apparatus of claim 31 wherein said second pair of contacts is engageable with said element to limit travel of said element in said upstream direction.

38. The apparatus of claim 29 further comprising a movable adjustor acting on said spring for adjusting said bias to accommodate a change in at least one system operating parameter.

39. An apparatus for detecting clogging in the fluid flow path of a fluid dispensing system of the type having a fluid dispenser which opens and closes intermittently in response to respective open and close signals, said apparatus comprising:

(a) a flow-restricting element in the flow path, said element being movable between an upsteam position and a downstream position;

(b) a spring acting on said element for biasing said element toward said upstream position with a force small enough to be overcome by an opposing force generated by the pressure drop across said element due to the flow of fluid traversing said element when the flow path is not clogged;

(c) a first pair of contacts actuatable in response to the presence of said element at said downstream position and a second pair of contacts actuatable in response to the presence of said element at said upstream position, and

(d) a controller connected to said dispenser and to said first and second pairs of contacts for monitoring the time difference between at least one of:

(i) the occurrence of the open signal and the displacement of said element to said downstream position, and

(ii) the occurrence of the close signal and the displacement of said element to said upstream position, and

for generating a signal indicative of a clogged condition in the event at least one of said time differences exceeds a predetermined limit.

40. The apparatus of claim 39 wherein said controller generates at least one of:

(i) a fully clogged signal in the event said element is located at said upstream position after a first time limit following the occurrence of said open signal, and

(ii) a partially clogged signal in the event said element is located intermediate said upstream position and said downstream position after at least one of:

(a) a second time limit following commencement of said open signal, and

(b) a third time limit following commencement of said close signal.

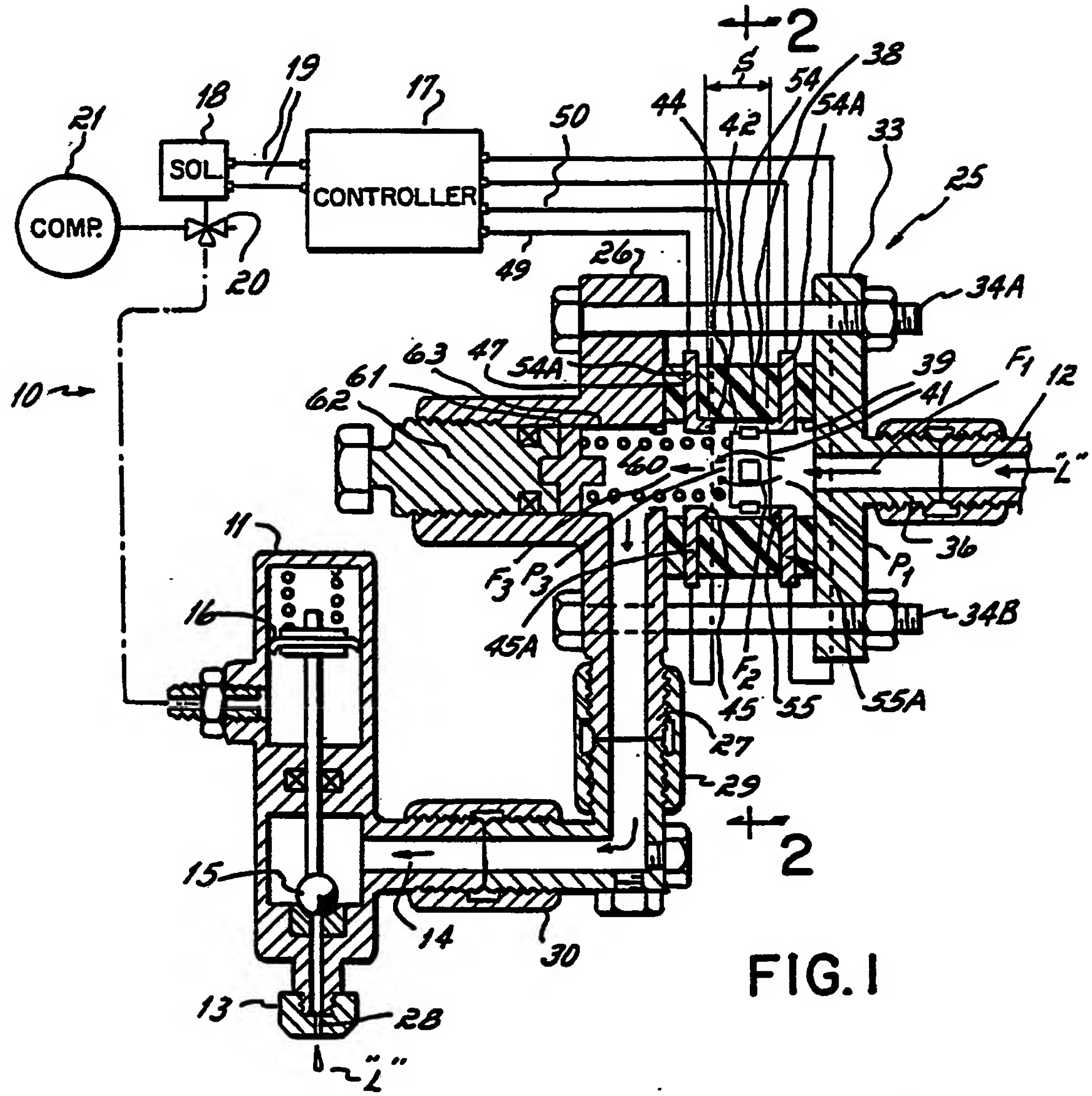

FIG. 1

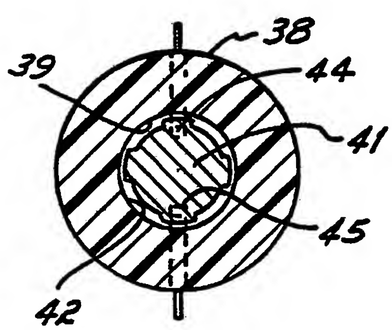

FIG. 2

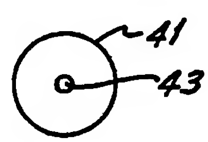

FIG. 3A

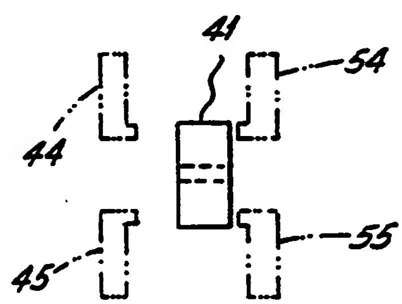

FIG. 3B

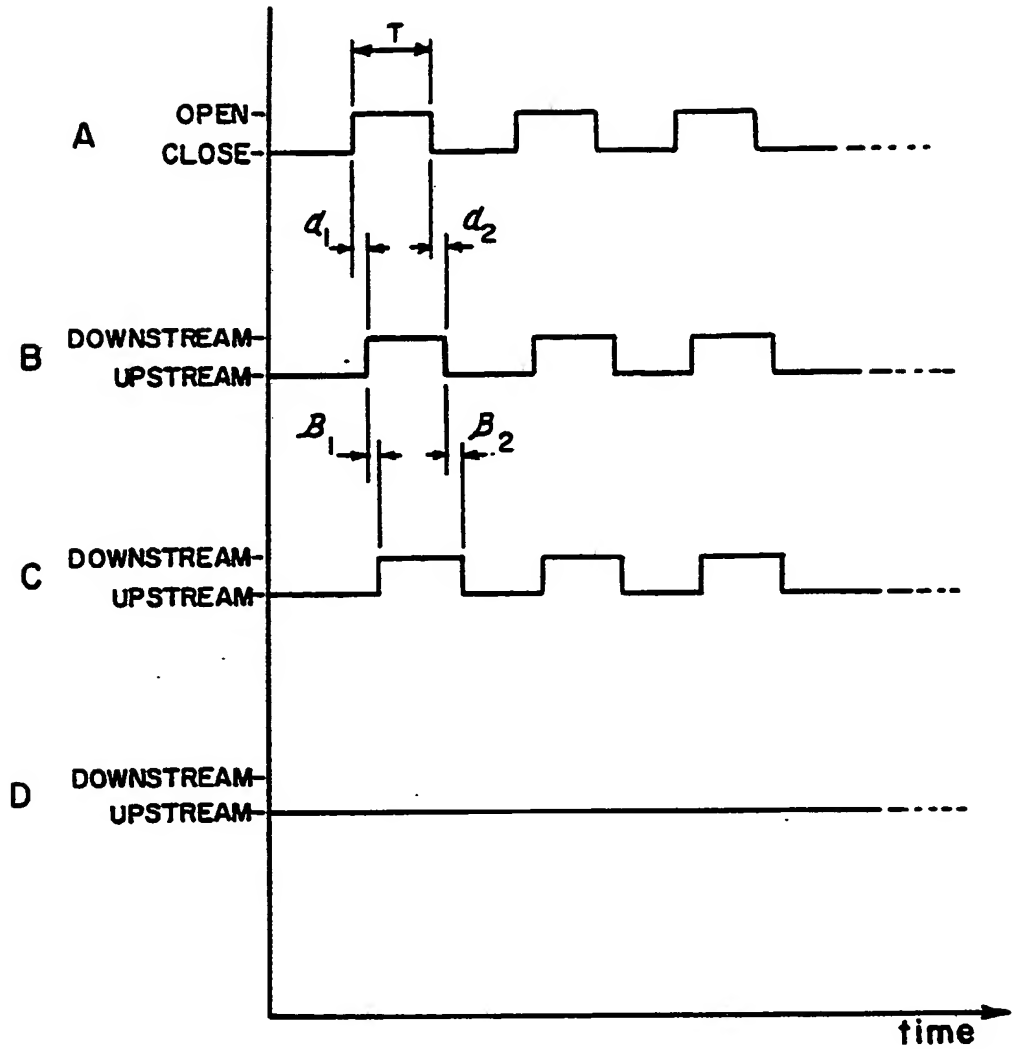
T
A
OPEN
CLOSE
d_1
d_2
B
DOWNSTREAM
UPSTREAM
β_1
β_2
C
DOWNSTREAM
UPSTREAM
D
DOWNSTREAM
UPSTREAM
time

FIG. 4

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US88/03404

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

U.S. C.L. 73/865.9; INT CL^4 G08B 21/00

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
US	73/865.9, 865.8, 37, 49.1, 861.05, 861.47, 861.52, 861.63, 861.64; 222/23, 40, 154; 137/557; 340/606, 607, 608; 239/71

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

Automated Patent System of U.S. Patent Office (Printout enclosed).

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X Y	US, A, 2,826,754 (Larignan) 11 March 1958, See Figs. 2, 3, 5 and col. 1, lines 22-26, and col. 2, lines 35+ (continuing on to col. 3, line 3)	1,2,6,7,16,17 20,21,29,31,34 37 3,5,8,18,19,22, 30,33,32,38
Y	US, A, 2,963,563,563 (Patterson) 06 December 1960, See Fig. 2, and col. 3, lines 43-47.	5,8,19,22,30, 33,32
A	US, A, 4,668,948 (Merkel) 26 May 1987	

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
11 December 1988	16 FEB 1989
International Searching Authority	**Signature of Authorized Officer**
ISA/US	Robert Raevis Robert Raevis